

CLAIMS

1. A piezoelectric transformer, characterized in that at least two piezoelectric substrates are connected via at least two connectors, each of said at least two piezoelectric substrates being formed of a piezoelectric material, having a plane plate shape and including a first main face and a second main face opposing thereto, wherein

said at least two piezoelectric substrates include a first piezoelectric substrate and a second piezoelectric substrate;

said first main face of one of said first piezoelectric substrate and said second piezoelectric substrate is disposed opposite to said second main face of the other one of said first piezoelectric substrate and said second piezoelectric substrate;

said at least two connectors and an air gap are provided between said first main face of said one of the piezoelectric substrates and said second main face of said other of the piezoelectric substrates; and

an input section is provided at said one of the piezoelectric substrates, and an output section is provided at said other of the piezoelectric substrates.

2. A piezoelectric transformer as recited in claim 1, characterized in that

said at least two connectors include a first connector, a second connector, and a third connector;

said air gap is provided between said first connector, said second connector, and said third connector;

each of said first piezoelectric substrate and said second piezoelectric substrate has a rectangular parallelepiped shape, and is divided into N equal regions (N is an integer which is equal to two or larger) in a longitudinal direction;

said first connector and said second connector are positioned at longitudinal end portions of said piezoelectric substrates; and

said third connector is positioned at a border of said regions of each of said first piezoelectric substrate and said second piezoelectric substrate.

3. A piezoelectric transformer as recited in claim 1 or 2, characterized in that

electrodes are respectively provided on said first main face and said second main face of said first piezoelectric substrate, and said first piezoelectric substrate between said electrodes is polarized in a direction perpendicular to

said first main face.

4. A piezoelectric transformer as recited in claim 1 or 2, characterized in that

said first piezoelectric substrate have a structure in which a plurality of electrode layers and a plurality of piezoelectric material layers each formed of a piezoelectric material are alternately laminated, said plurality of electrode layers are grouped into two electrode groups, and said electrode layers within the same electrode group are electrically connected to each other.

5. A piezoelectric transformer as recited in claim 2, characterized in that

electrodes are respectively provided at both ends in said longitudinal direction and at the border between said regions of at least one of said first piezoelectric substrate and said second piezoelectric substrate, said piezoelectric substrate between said electrodes is polarized parallel to said longitudinal direction, and polarization directions of said regions adjacent to each other are mutually opposite in parallel.

6. A piezoelectric transformer as recited in claim 2,

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characterized in that

each of said regions of said first piezoelectric substrate or said second piezoelectric substrate has a structure in which a plurality of electrode layers and a plurality of piezoelectric material layers formed of a piezoelectric material are alternately laminated in a thickness direction of said first piezoelectric substrate or said second piezoelectric substrate,

said piezoelectric material layer between said electrodes in each of said regions is polarized parallel to said thickness direction,

polarization directions of said piezoelectric material layers adjacent to each other in said thickness direction are mutually opposite in parallel,

said plurality of electrode layers in said each region are grouped into two electrode groups, and said electrode layers within the same electrode group are electrically connected to each other.

7. A piezoelectric transformer as recited in claim 2, characterized in that

each of said regions of said first piezoelectric substrate or said second piezoelectric substrate has a structure in which a plurality of electrode layers and a

plurality of piezoelectric material layers formed of a piezoelectric material are alternately laminated in said longitudinal direction,

said piezoelectric layer between said electrodes in each of said regions is polarized parallel to said longitudinal direction,

said plurality of electrode layers in said each region are grouped into two electrode groups, and said electrode layers within the same electrode group are electrically connected to each other.

8. A piezoelectric transformer as recited in any one of claims 1 to 7, characterized in that

an electrical connection portion, which is to be connected to an external circuit, of said input section is formed on a side face along said longitudinal direction and at a vibrational node portion in said longitudinal direction of said one of said piezoelectric substrates;

an electrical connection portion, which is to be connected to the external circuit, of said output section is formed on a side face along said longitudinal direction and at a vibrational node portion in said longitudinal direction of said other of said piezoelectric substrates; and

an electrical connection between said electrical

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connection portion, which is to be connected to the outside, of said input section and said external circuit and an electrical connection between said electrical connection portion, which is to be connected to the outside, of said output section and said external circuit, and mechanical connections to support the piezoelectric transformer are performed via conductors.

9. A piezoelectric transformer, characterized by comprising:

at least two piezoelectric substrates respectively including two main faces opposite to each other, said at least two piezoelectric substrates including a first piezoelectric substrate and a second piezoelectric substrate, and

a connector either formed or disposed as a ring in which an air gap is provided, wherein

said first piezoelectric substrate and said second piezoelectric substrate are disposed such that said main faces of said first and second piezoelectric substrates are opposed to each other, and said first and second piezoelectric substrates are connected together between said main faces via said connector; and

an input section is provided in said first piezoelectric substrate, and an output section being provided

in said other of said piezoelectric substrates.

10. A piezoelectric transformer as recited in claim 9, characterized in that said connector provided between said first piezoelectric substrate and said second piezoelectric substrate is positioned at a vibrational loop portion of a radially-expanding vibration of said first piezoelectric substrate and said second piezoelectric substrate.

11. A piezoelectric transformer as recited in claim 9 or 10, characterized in that

an electrode is provided on each of said two main faces of each of said first piezoelectric substrate and said second piezoelectric substrate, and said first piezoelectric substrate and said second piezoelectric substrate are respectively polarized in a direction perpendicular to said main faces.

12. A piezoelectric transformer as recited in claim 9 or 10, characterized in that

a circular electrode is provided at a central portion of at least one of said main faces of at least one of said first piezoelectric substrate and said second piezoelectric substrate,

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a ring-like electrode is provided at an outer edge portion of said at least one of said main faces of said at least one of said first and second piezoelectric substrates, and said at least one of said first piezoelectric substrate and said second piezoelectric substrate between said circular electrode and said ring-like electrode is polarized in a radial direction.

13. A piezoelectric transformer as recited in claim 9 or 10, characterized in that

at least one of said first piezoelectric substrate and said second piezoelectric substrate has a structure in which a plurality of electrode layers and a plurality of piezoelectric material layers formed of a piezoelectric material are alternately laminated in a thickness direction, said plurality of electrode layers are alternately electrically connected, and the electrode layers adjacent to each other are insulated in terms of direct current.

14. A piezoelectric transformer, characterized in that

at least two piezoelectric substrates having a plane plate shape and made of a piezoelectric material are connected via at least one connector having a disk shape and made of an insulating material,

said at least two piezoelectric substrates include a first piezoelectric substrate and a second piezoelectric substrate,

said first piezoelectric substrate and said second piezoelectric substrate are connected via said connector of said at least one connector; and

an input section is provided in one of said first piezoelectric substrate and the aforementioned second piezoelectric substrate, an output section being provided in the other of said first and second piezoelectric substrates.

15. A piezoelectric transformer as recited in claim 14, characterized in that

said first piezoelectric substrate and said second piezoelectric substrate respectively include a first main face and a second main face,

an electrode layer is provided on each of said first main face and said second main face of each of said first piezoelectric substrate and said second piezoelectric substrate, and

said first piezoelectric substrate and said second piezoelectric substrate between said electrode layers are respectively polarized in a direction perpendicular to said first main faces.

16. A piezoelectric transformer as recited in claim 14, characterized in that

at least one of said first piezoelectric substrate and said second piezoelectric substrate has a structure in which a plurality of electrode layers and a plurality of piezoelectric layers formed of a piezoelectric material are alternately laminated in a thickness direction, and said plurality of electrode layers are grouped into two electrode groups in which said electrode layers are alternately electrically connected.

17. A piezoelectric transformer as recited in claim 15 or 16, characterized in that

said electrode layers provided on said first piezoelectric substrate and said second piezoelectric substrate have circular shapes.

18. A piezoelectric transformer as recited in any one of claims 14 to 17, characterized in that

said first main faces and said second main faces of said first piezoelectric substrate and said second piezoelectric substrate have square shapes and a center of a circle drawn to be inscribed in said square coincides with

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a center of said connector provided between said first piezoelectric substrate and said second piezoelectric substrate.

19. A piezoelectric transformer as recited in any one of claims 14 to 16, characterized in that

sizes of main faces of said connector, which are opposed to said main faces of said first piezoelectric substrate and said second piezoelectric substrate, are equal to or smaller than circles drawn to be inscribed in peripheries of said main faces of said first piezoelectric substrate and said second piezoelectric substrate.

20. A piezoelectric transformer as recited in claim 1, 2, 9 or 14, characterized in that

said at least two piezoelectric substrates further include a third piezoelectric substrate,

said third piezoelectric substrate is set to be either the input section or the output section, and

said first to third piezoelectric substrates are disposed so that the input section and the output section are disposed mirror symmetric.